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SOLAR POWERD AIR QUALITY MONITORING SYSTEM

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Abstract: Air pollution is an increasing environmental issue that has a great impact on human health and the environment to mitigate this problem the solar-powered air quality monitoring system presents a novel solution for real-time monitoring of environmental factors like temperature humidity and toxic gases the system is solar powered at the core of the system lies the esp32 microcontroller that connects two main sensors the dht11 sensor to provide temperature and humidity data and the mq135 sensor for sensing air contaminants the sensed data is filtered and displayed on a 16x2 lcd display for instantaneous local monitoring the system is also integrated into the blynk app such that remote air quality data can be monitored from a smartphone the system is made to be energy and eco- friendly using solar power as its main source of energy it is an effective tool in creating awareness regarding air pollution and improving public health through timely action the system can be best applied in urban and rural environments where air quality changes and access to power infrastructure might be lacking in conclusion the solar-powered air quality monitoring system offers a practical sustainable and real-time method of monitoring environmental conditions leading to cleaner air and healthy communities.

I. INTRODUCTION

The solar-powered environmental monitoring system is an eco-friendly solution to monitoring environmental parameters like temperature humidity and toxic gases the system revolves around an esp32 microcontroller that takes input from a dht11 sensor temperature and humidity and an mq135 sensor for measuring air pollutants solar- powered the system operates without a break in off- grid locations the data gathered is shown on a 16x2 lcd display for real-time monitoring locally and can also be remotely viewed via the blynk app which makes monitoring air quality possible from anywhere the blynk integration with the system means that users get real-time data on their smartphones making the system perfect for urban and rural locations where air quality could fluctuate or decline the buck converter and solar panel make the system energy- efficient utilizing power from renewable sources making it eco-friendly the system is especially convenient for air quality monitoring in remote areas where conventional power sources are not accessible through use of this intelligent technology the system boosts air pollution awareness and helps to create a healthier cleaner environment detecting dangerous pollutants and environmental shifts in real time.

II. Literature Survey

The evolution of autonomous environmental monitoring systems has picked up immense interest because of the increasing need to minimize air pollution and reduce its harmful impact on public health. Investigators have demonstrated numerous methods for air monitoring through Internet of Things (IoT) technologies, solar energy, and energy-saving components.

In [1], an iot-based air quality monitoring system using low-cost sensors such as mq135 to sense air quality was developed. The system was based on the communication of wi-fi through an esp8266 module sensor reading to a blynk server for real-time monitoring to overcome these limitations solar powered alternatives have been explored in literature.

In [2], a solar-powered air quality monitoring system was proposed which employed an esp32 this system worked effectively off-grid using solar power but its dependency on a small-scale battery and lack of sophisticated communication features like blynk integration restricted its scalability and long-term deployment subsequent developments have included more advanced components including the esp32 which provides both wi-fi and Bluetooth connectivity for wireless communication.

In [3], a solar-powered system based on esp32 was designed to track environmental parameters like temperature humidity and air quality the system also included a local lcd display for real-time feedback although the system offered considerable improvement in remote data monitoring it encountered difficulties in sensor calibration and energy management besides solar- based systems researchers have also investigated hybrid energy models to increase the sustainability and efficiency of air quality monitoring systems.

In [4], Research in suggested integrating a battery management system with solar panels and energy-efficient microcontrollers. The system employed a buck converter to step down the battery voltage to the appropriate voltage levels for the esp32 and sensors. This design not only prolonged the systems operating life but also made it possible for the components to have a stable power supply during different environments.

III. SYSTEM REQUIREMENTS

➤ Node MCU ESP32

The ESP32 series employs either a variation Xtensa LX6 microprocessor in both dual-core and single-core variations, an Xtensa LX7 dual-core microprocessor, a includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. a system on a chip that integrates the following features: Wi-Fi (2.4 GHz band) Bluetooth. Dual high performance Xtensa 32-bit LX6 CPU cores. Ultra Low Power co-processor. It is commonly found either on device-specific PCBs or on a range of development boards with GPIO pins and various connectors depending on the model and manufacturer of the board.



Figure 3.1: Node MCU ESP32

➤ MQ135 SENSOR

A device that is used to detect or measure or monitor the gases like ammonia, benzene, sulphur, carbon dioxide, smoke, and other harmful gases are called as an air quality gas sensor. The MQ135 air quality sensor, which belongs to the series of MQ gas sensors, is widely used to detect harmful gases, and smoke in the fresh air. This article gives a brief description of how to measure and detect gases by using an MQ135 air quality sensor.

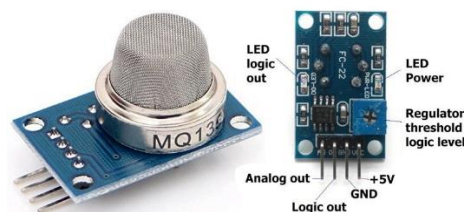


Figure 3.2: MQ135 Sensor

➤ DHT11 SENSOR

The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of $\pm 1^\circ\text{C}$ and $\pm 1\%$.

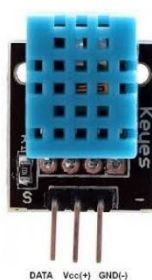


Figure 3.3: DHT11 Sensor

➤ 16x2 LCD DISPLAY

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment light-emitting diodes and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations.

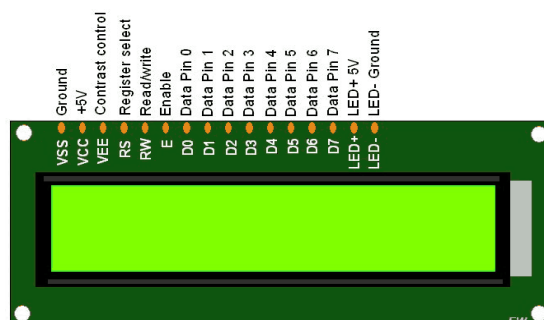


Figure 3.4: 16x2 LCD Display

➤ SOLAR PANEL

The main component of a solar panel is a solar cell, which converts the Sun's energy to usable electrical energy. The most common form of solar panels involves crystalline silicon-type solar cells. These solar cells are formed using layers of elemental silicon and elements such as phosphorus and boron. The elements added to the silicon layers form an n-type layer, which has an excess of electrons, and a p-type layer, which has a deficit of electrons. These two layers form a p-n junction.



Figure 3.5: Solar Panel

➤ LITHIUM-ION BATTERY

A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible intercalation of Li^+ ions into electronically conducting solids to store energy. In comparison with other commercial rechargeable batteries, Li-ion batteries are characterized by higher specific energy, higher energy density, higher energy efficiency, a longer cycle life, and a longer calendar life. Also noteworthy is a dramatic improvement in lithium-ion battery properties after their market introduction in 1991 over the following 30 years, their volumetric energy density increased threefold while their cost dropped tenfold.

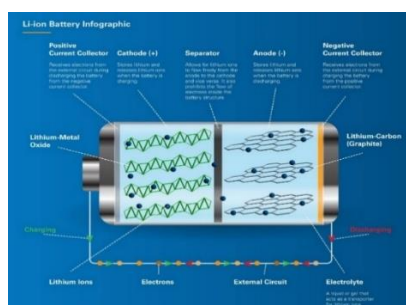


Figure 3.6: Lithium-ion Battery

➤ I2C CONVERTER

I2C Interface Adapter Module is used for 16×2 LCD Display. It uses the PCF8574T IC chip which converts I2C serial data to parallel data for the LCD display. Also, this interface module simplifies connecting an Arduino to a 16×2 Liquid Crystal display using only 4 wires.

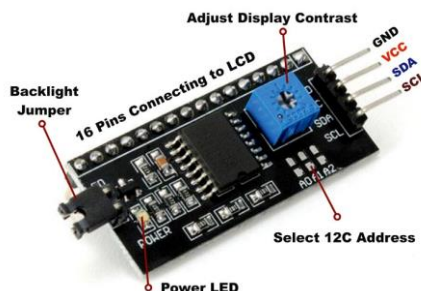


Figure 3.7: I2C Converter

➤ VOLTAGE CONTROLLER

The XL6009 is a versatile DC-DC adjustable boost-buck (step-up/down) power module commonly used to regulate and convert voltage in embedded and DIY electronics. It can boost and regulate the voltage depending on your circuit needs.



Figure 3.8: Voltage Controller

➤ BUCK CONVERTER

A buck converter or step-down converter is a DC-to-DC converter which decreases voltage, while increasing current, from its input (supply) to its output (load). It is a class of switched-mode power supply. Switching converters (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulators, which are simpler circuits that dissipate power as heat, but do not step up output current. The efficiency of buck converters can be very high, often over 90%, making them useful for tasks such as converting a computer's main supply voltage, which is usually 12 V, down to lower voltages needed by USB, DRAM and the CPU, which are usually 5, 3.3 or 1.8 V.



Figure 3.9: Buck Controller

IV. ARCHITECTURE

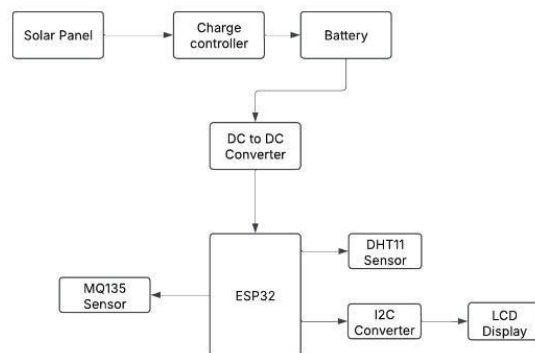


Figure 4.1: Architecture of Solar Powered Air Quality Monitoring System

Figure 3.1 shows the architecture of a Solar powered air quality monitoring system. The esp32-based solar-powered environmental monitoring system the system should be able to run independently based on renewable power from a solar panel where sunlight is used to generate electricity this energy is controlled by a charge controller to provide secure charging of a rechargeable battery the energy stored in the battery is then supplied to a dc-to-dc converter which reduces or regulates the voltage to a level appropriate for the esp32 and the components connected to it the esp32 microcontroller is the main processing unit of the system it gathers environmental information through two main sensors the dht11 sensor used to measure temperature and humidity and the mq135 sensor used to identify air quality by detecting harmful gases like co2 and nh3 the data is filtered by the esp32 and transferred to an lcd display to be monitored in real-time an i2c converter is employed to make it easy to connect the lcd to the esp32 this configuration is suitable for off grid or remote areas where round-the-clock power supply is difficult the combination of solar power and low-power devices makes the system green and sustainable.

V. FLOWCHART

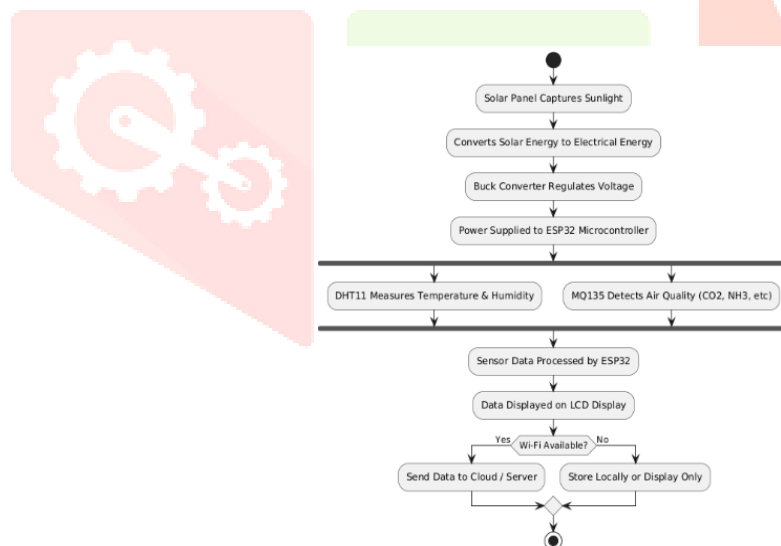


Figure 5.1: Flowchart of Solar Powered Air Quality Monitoring System

VI. RESULT & DISCUSSION



Figure 6.1: Air quality monitoring model.

The deployed solar powered air quality monitoring system effectively monitors and measures important environmental parameters like temperature humidity and air quality index in real-time the system effectively detects changes in atmospheric conditions and pollutant concentrations using the dht11 sensor and mq135 gas sensor the collected data is shown on a 16x2 lcd display and also sent to the blynk iot platform simultaneously through the esp32 microcontroller solar energy application guarantees uninterrupted operations in remote or outdoor locations fostering sustainability test results conducted in different environments indicated the capability of the system to identify increased pollution levels in parts per million and initiate alarms the logged data in blynk also offers trend and historical data for advanced analysis discussion shows that if the system is operating under a normal daylight condition. The performance of the system can be affected by solar intensity sensor calibration and network stability. The practicality of the system in real-time environmental monitoring is demonstrated through the integration of wireless iot communication and renewable energy.

VII. INITIAL TESTS

When the weather gets altered the sensor will show the values on the lcd the reading when the model kept outside the room can be viewed in the fig 7.1 and fig 7.2 indicates the reading when the device is kept within the room the temperature is referred to as temp humidity as hum the inlet and outlet sensor values are indicated in the second line when the inlet gas sensor value is viewed as indicated in fig 7.3 the difference between the inlet and outlet sensor readings can be viewed on the lcd display to run this unit smoke is fed into the chamber to mimic dirty air as shown in fig7.4 the lcd shows that the air is good figure 5 air quality model positioned outside room for collection of real- time environmental data figure 6 air quality model positioned inside room



for real-time environmental data acquisition figure 7.3 gas sensor analogy values recorded during real-time air quality monitoring figure 7.4 lcd display indicating the air quality level as good.

Figure 7.1: Air Quality model positioned outside room for collection of real-time



environmental data.

Figure 7.2: Air Quality model positioned inside room for real-time environmental data acquisition.



Figure 7.3: Gas sensor analogy values recorded during real-time air quality monitoring.



Figure 7.4: LCD display indicating the air quality level as Good based on real-time sensor data processed by the ESP32.

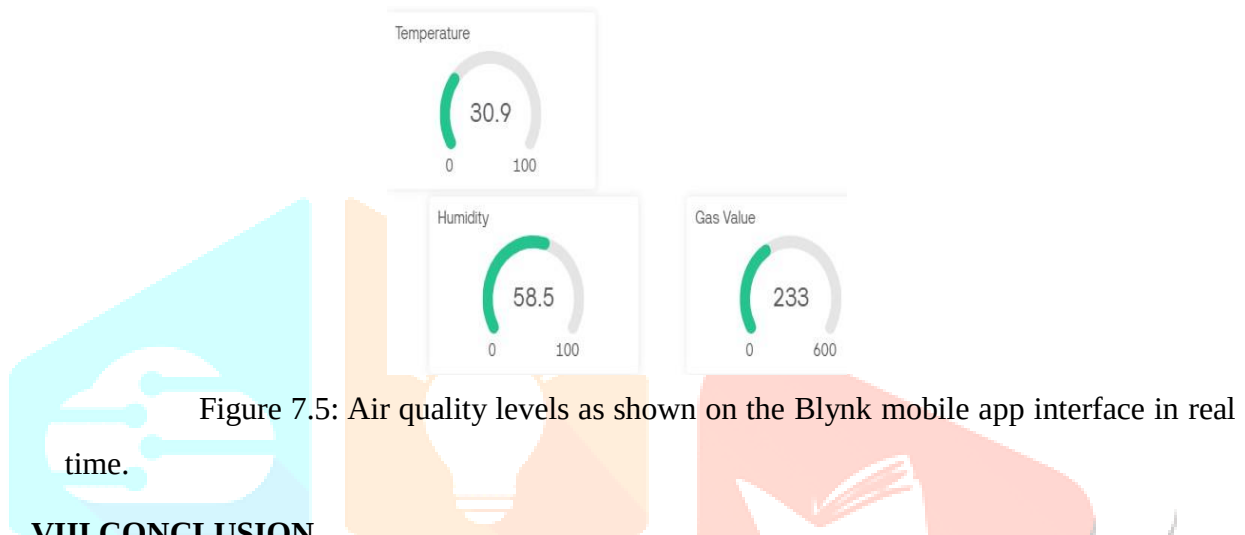


Figure 7.5: Air quality levels as shown on the Blynk mobile app interface in real time.

VIII.CONCLUSION

The solar powered air quality monitoring system is a cost-effective eco-friendly and efficient system for real-time environmental pollution monitoring with the use of sensors like dht11 and mq135 combined with the esp32 microcontroller the system accurately measures temperature humidity and concentrations of harmful gases such as co the inclusion of a solar panel and voltage regulators facilitates uninterrupted functioning even in remote or off-grid locations furthermore the use of blynk iot platform provides real-time data visualization as well as mobile alertness on smartphones thus making the system extremely user- friendly and accessible the project illustrates how iot renewable energy and environmental sensing can be integrated together to create smart solutions for public health and pollution management the system can be further extended with additional sensors and ai-driven analysis in the future to forecast pollution patterns and aid in decision-making for urban planning and environmental conservation.

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